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Directional preference of European lobster (*Homarus gammarus*) movements on the Yorkshire Coast

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Abstract

Recaptures of 838 tagged *Homarus gammarus* individuals identified a directional preference, with bearings from release to recapture concentrated along a North-West to South-East axis, aligning with the predominant current direction for the study site.

Keywords: *Homarus gammarus*; directional preference; tagging

INTRODUCTION

A contemporary approach to the management of UK crustacean stocks has been the application of localised spatial management systems, which have been utilised in a series of areas to restrict either total extractions or effort capacity (Smith 2010). The European lobster, *Homarus gammarus* (Linnaeus 1758) has been proposed as a favourable candidate for these spatial systems, as the species is considered to exhibit a strong site fidelity and are a main target species for concentrated static pot fisheries (Moland *et al.* 2011; Smith *et al.* 2001; Bannister *et al.* 1994). However movement patterns of *H. gammarus* are relatively unknown with behavioural inferences mainly drawn from small scale experimentation, short-term assessments or historic trials (Skerrit *et al.* 2013; Moland *et al.* 2011; Bannister *et al.* 1994; Hepper 1978). This communication outlines a significant observation of *H. gammarus* movements from a mass tag and recapture programme, identifying that movements within the study stock were subject to directional preferences.

METHODOLOGY

To determine the movement patterns and general dispersions trends of *H. gammarus,* 10,000 individuals were tagged and released from 2007 to 2009 by offshore observers accompanying commercial fishing vessels. Animals were released in a strategic manner with releases spread over five general survey areas of the Yorkshire Coast study site (Figure 1). Monthly research trips were scheduled over April to October in each survey area, with the targeted tagging of 90 individuals per research trip. A standardised tagging regime and size distribution was used to allow for the assessment of the entire *H. gammarus* population accounting for sex and size (90 animals per survey, 18 individuals per 10 mm carapace length grouping, ranging from 65 mm to a 96 mm plus group, with 50:50 sex ratio). Individuals of 85 mm carapace length or more were 'v-notched' in an inner uropod, providing protection through a national byelaw for an estimated two moults, with commercially saleable animals of 87 mm or more purchased from the vessel at market price.

Lobsters were individually tagged using polyethylene streamer tags (Hallprint Ltd) which were administered invasively with a stainless steel needle through the abdominal musculature between the first segment of the abdomen and carapace, allowing for retention through multiple moults. Tags were sequentially numbered so each individual could be identified, with release co-ordinates, carapace length (mm), sex, moult status, limb loss, presence of eggs and condition recorded for all individuals. Once tagged, animals were released as close as possible to their capture location. The project was advertised to regional stakeholders, who provided information on tag number, location, sex, carapace length and presence of eggs for reported recaptures.

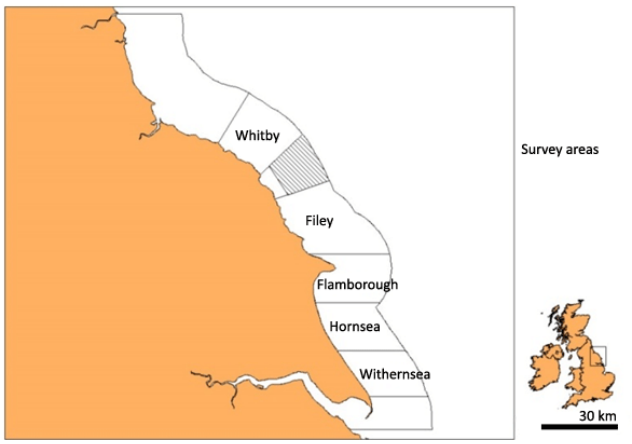

Figure 1: The Yorkshire Coast study site and individual survey areas

Rao's Spacing Test of Uniformity was applied to assess whether the underlying distribution of movement direction was uniform (Agostinelli and Lund 2011). Movements were assessed collectively, then disaggregated and assessed by sex to account for noted behavioural differences that may influence movements, with all analysis and transformation developed in R (R Development Core Team 2011; Freitas 2010; Smith 2010). A 5 km per day threshold was used to account for operators transhipping tagged animals, determined by the assessment of high confidence recaptures. Sets of recapture details without complete information were not included in the analysis and recaptures reported on the same day as the animal was released were also discounted. Recapture analysis was developed using pooled recapture data from the 2007 to 2010, to mediate for the annual variability in environmental and anthropogenic factors influencing the fishery, including significant weather impacts during 2009 surveys.

RESULTS AND DISCUSSION

1,309 recaptures were recorded over a 4 year survey period (13 %), with 838 sets of recapture details containing sufficient detail for comprehensive analysis following quality assurance, consisting of 552 males and 286 females (Table 1). There was no significant difference in male and female recapture frequency (Pearson's Chi Square Test, df = 4, χ^2 = 9.008, *p>0.05;* Table 1).

Table 1: A summary of *H. gammarus* recaptures by release survey area and sex, detailing total recaptures frequency from 2007 to 2010

Recaptures (No.)	*Whitby*	*Filey*	*Flamborough*	*Hornsea*	*Withernsea*
Total	96	135	302	179	126
Male	72	83	201	107	89
Female	24	52	101	72	37

Analysis of animal movements from release to recapture determined that *H. gammarus* dispersion was not uniform, with visual inspection indicating multi-modal distributions clustering between the North to West and South to East cardinals (Rao's Spacing Test of Uniformity n=838*,* U=158.827, *p<0.05,* Figure 2a). Disaggregation and analysis by sex determined that neither male (Rao's Spacing Test of Uniformity; n=552*,* U=155.755*, p<0.05*) or female (Rao's Spacing Test of Uniformity n=286, U=163.657*, p<0.05*) movements were uniform. The main distributions of male movements were between the North to West and South to East cardinals, with a concentration of movements travelling East to South-East (Figure 2b). Female movements displayed a general bi-modal distribution, with the majority of recaptures evenly distributed between the North to West and South to East cardinals (Figure 2c).

Movements orientated to this axis complement the predominant currents in region, suggesting that *H. gammarus* movements may be influenced by current direction. Consideration should be given to *H. gammarus* olfaction, where current processes govern the transportation and therefore concentration of scent cues in the water column, which may influence an individual's behaviour and therefore choice of movement direction (Skog 2009; Barshaw *et al.* 2003). As release sites varied across the study area up to 12 nautical miles offshore, the geographical constraints of the coastline did not appear to impact *H. gammarus'* ability to move in a westerly direction inshore. In consideration of this study's results and its broader implications for *H. gammarus* management, they support the hypothesis that broadscale movements can be estimated based upon regional current systems. If this directional preference is a common feature of *H. gammarus* stocks then it could be used by fisheries managers to predict animal movements, allowing for the more informed assessment and interpretation of seasonal fishing activity and stock exploitation.

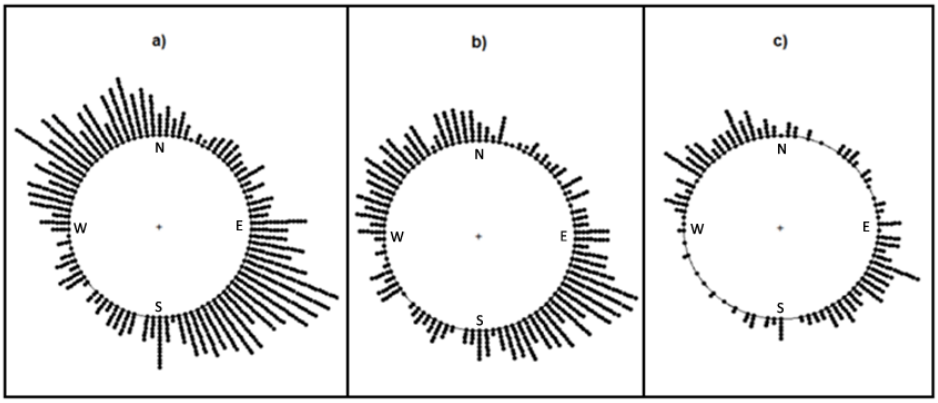

Figure 2: Ordinal plots of movement bearings by for (a) total recaptures, (b) male recaptures and (c) female recaptures. Individual points represent the bearing from release to recapture position and are presented as stacked columns in 5° increments

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